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Technical Report 793

# Recruit Quality, Soldier Performance, and Job Assignment

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U. S. Army

Research Institute for the Behavioral and Social Sciences

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A conceptual framework to link multiple measures of recruit performance and costs with job assignments was developed. Data envelopment analysis was used to construct an index of performance. Statistical analyses were then performed to examine the relationship of recruit characteristics to the performance index. Results were that enlistment test scores predicted performance, but education did not. Keywords:


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# Recruit Quality, Soldier Performance, and Job Assignment

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Manpower, Personnel, and Training

## FOREWORD

The Manpower and Personnel Policy Research Group is concerned with the assignment of recruits to Military Occupational Specialties and with their expected performance. This research examines a way in which a multidimensional measure of soldier performance can be created and investigates its implications for making improved job assignments.

EDGAR M. JOHNSON
Technical Director

RECRUIT QUALITY, SOLDIER PERFORMANCE, AND JOB ASSIGNMENT


## EXECUTIVE SUMMARY

Requirement:

The relationship between recruit quality and actual soldier performance is an issue of continuing interest to both Army and congressional policy makers. Information about the strength of this relationship and the degree to which the characteristics measured by the Armed Forces Qualification Test (AFQT) and educational attainment vary in importance across Army jobs is particularly important in two areas: (a) properly allocating resources among the tasks of recruiting, training, and equipping soldiers and (b) matching soldiers with jobs in a way that makes the best possible use of the shrinking pool of available recruits. → 1473

Previous research on this issue has focused on estimating the links between recruit quality and a variety of single-dimensional measures of soldier performance. The present research seeks to extend that work by using a multidimensional measure of soldier performance and embedding the analysis in a theoretical framework that allows the implications of the quality-performance links for job assignment and resource allocation to be assessed.

Procedure:

The research proceeded as follows: A conceptual framework linking a multidimensional measure of performance with recruit quality, recruitment costs, and job assignment was developed; a new technique (Data Envelopment Analysis) for constructing a multidimensional soldier performance measure was demonstrated; and the relationship between this measure of performance and recruit quality in four large Army specialties was examined using regression analysis. (The MOS analyzed were infantryman (11B), armor crewman (19E), wheel vehicle mechanic (63B), and medical specialist (91A)).

Findings:

The research shows that a multidimensional performance index can be constructed, and that such an index captures components of performance that elude the more widely used unidimensional measures. A conceptual framework linking soldier performance with recruit quality and job assignment is developed and used to show how marginal productivity can be linked to marginal recruiting costs.

The empirical results found here are consistent with those of earlier studies in that AFQT scores are shown to be consistently predictive of soldier

performance. HSDG status does not predict multidimensional soldier performance among the soldiers in the sample. (This result may be due to the selection resulting from differences in attrition rates between high school graduates and nongraduates.)

Elasticities of performance with respect to changes in recruit quality are estimated for each of the four MOS examined. These results suggest that increases in recruit quality generate the largest increases in expected job performance in MOS 91A, followed by 11B, 19E, and 63B.

Utilization of Findings:

The primary purpose of this research was exploratory. Accordingly, the results will be applied mainly as a foundation for further research. The findings are expected to be most useful in two areas: developing new approaches to the problem of estimating marginal returns to recruitment expenditures and integrating performance measurement and performance valuation in the context of selection, classification, and assignment research.

RECRUIT QUALITY, SOLDIER PERFORMANCE, AND JOB ASSIGNMENT

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# RECRUIT QUALITY, SOLDIER PERFORMANCE, AND JOB ASSIGNMENT

## INTRODUCTION

Heightened concern for the quality of the armed forces and soldier performance has focused attention in recent years on the issues of military productivity, recruit quality (measured by test scores and education), and job assignment. The relationship between mental aptitude of military personnel and job performance or productivity is supported by the recent research of Wallace (1982), Eden and Tziner (1982), Tziner and Vardi (1982), and Scribner, Smith, Baldwin and Phillips (1986). This research shows that tank performance is positively related to the quality of the tank crew, as measured by the Armed Forces Qualifications Test (AFQT) scores of the tank commander and gunner. Daula and Baldwin (1984) also show that years of education and AFQT score are positively related to expected years of first term service.

Recruiting high-quality personnel is costly, however, because of competing employment opportunities in the private sector. Cost of recruitment must therefore be related to the utility of a recruit of a given quality when assigned to a particular job. Job assignment is therefore a key link between the cost of recruiting quality personnel and their productivity and utility on the job.

This paper has three objectives: First, to develop a conceptual framework that links the quality of recruits to job performance and the cost of recruitment with the value (utility) of performance. Second, to demonstrate the use of a data envelopment procedure to obtain a multidimensional index of job performance; and finally, to estimate the sensitivity of this multi-dimensional measure of job performance to variations in recruit quality within and across jobs.

## DEFINITION OF THE PROBLEM

To define the research problem we introduce formal notation. Let

$q$ = Quality of a recruit

$t$ = Amount of training provided after recruitment

$x$ = Other non-training attributes of a recruit that are determinants of performance

$c(q,t)$ = Cost of recruitment and training

$p(q,t,x)$ = Performance or productivity of a soldier

$u(p,c)$ = Utility or value of a soldier in a given job (MOS).

By total differentiation of $u(p,c)$ we have

$$du = \frac{\partial u}{\partial p} dp + \frac{\partial p}{\partial c} dc \tag{1}$$

where $\partial u/\partial p > 0$ and $\partial u/\partial c < 0$ (i.e. higher performance is desirable, and higher costs are undesirable). This implies that, if utility is held constant ($du=0$), then $dp/dc > 0$; that is, for a given level of utility, the change in performance ($dp$) due to a very small change in recruitment and training cost ($dc$) is positive.

By maintaining a constant training level, $dt = 0$, and no change in other characteristics of recruits, $dx = 0$, we can write the first order differentials

$$dp = \frac{\partial p}{\partial q} dq \tag{2}$$

$$dc = \frac{\partial c}{\partial q} dq. \tag{3}$$

Next, by inserting (2) and (3) into (1), we obtain

$$du = \frac{\partial u}{\partial p}\frac{\partial p}{\partial q} dq + \frac{\partial u}{\partial c}\frac{\partial c}{\partial q} dq \tag{4}$$

implying

$$\frac{du}{dq} = \frac{\partial u}{\partial p}\frac{\partial p}{\partial q} + \frac{\partial u}{\partial c}\frac{\partial c}{\partial q} \tag{5}$$

with gain in utility due to increase of quality (i.e., $du/dq \geq 0$) possible as long as

$$\frac{\partial p/\partial q}{\partial c/\partial q} \geq - \frac{\partial u/\partial c}{\partial u/\partial p}. \qquad (6)$$

Thus, in order to determine whether it is worthwhile to increase the quality of recruits, the ratio of the marginal gain in productivity ($\partial p/\partial q$) to marginal cost of increased quality ($\partial c/\partial q$) must exceed the ratio of the marginal disutility of recruitment cost ($-\partial u/\partial c$) to the marginal utility of performance gain ($\partial u/\partial p$). The right-hand side of equation (6) requires estimates of the utility of soldier performance in a given job along with the opportunity cost evaluation (or disutility) of expanding additional recruitment resources on one job as opposed to another. The left-hand side requires measures of soldier performance, cost of training and recruitment, and mental and physical aptitude of soldiers.

In this paper we shall concern ourselves principally with developing estimates for the left-hand side of equation (6); the measurement of the right-hand side of the equation will be addressed in a sequel to this paper.

## CONCEPTUAL FRAMEWORK

The methodology employed in this paper is intended to provide the basis for an integrated approach to the measurement of both soldier performance itself and the job-specific value of that performance. The empirical analysis undertaken here is focused on the measurement of performance and its relationship to widely-used mesaures of recruit quality. However, the choice of methodology to carry out the analysis was motivated by the long-term objective of combining multi-dimensional performance measurement, performance evaluation, and job assignment within a single framework. The purpose of this section is to sketch the outlines of that framework.

### Performance Measurement

Consider an example in which performance is defined by two dimensions or attributes:

$P_1$ = "job knowledge" (JK), and

$P_2$ = "adaptability" (AD).

We can imagine that "job knowledge" is a measure of the extent to which a soldier can correctly perform specific job tasks, while "adaptability" is a measure of how well the soldier functions in the organizational and social context within which those tasks must be performed. We shall limit our discussion here to these two dimensions to allow the use of two-dimensional graphs. In practice, of course, performance is likely to be made up of several dimensions.

In Figure 1 we show how $P_1$ and $P_2$ may be used to form a soldier performance space. Points A, B and C locate three soldiers in that space. Soldiers A and B are located on a ray passing through the origin with the same mix (ratio) of performance attributes, $P_1/P_2$. A is clearly a superior performer in both dimensions. Soldier C differs from A in that C is a better performer on $P_2$ but inferior on $P_1$.

Although A and C differ in their performance attributes, both are located on a "performance frontier" formed by the curve shown in Figure 1. The performance frontier forms a trade-off surface between the performance attributes of the best soldiers. A and C are superior soldiers since no single attribute can be improved without a "trade-off" of the other attribute.

By contrast, Soldier B's performance on both dimensions, when compared to A's, can be considerably improved. The ratio of the distance of both points from the origin OB/OA may be used as an index of relative performance for soldiers of that JK/AD skill ratio. Soldier B, and all other soldiers located on the interior of the performance frontier, will have an index of less than 1.0 (say, 0.7 for B), while soldiers A and C, who are on the performance frontier, will have an index of 1.0.

The components of performance may contribute differently to overall performance in one job than in another -- that is, the most <u>productive</u> mix of attributes may vary across jobs. In this case, we would observe different performance frontiers representing the fact that the maximum level of output attainable from a given mix of performance "inputs" is not the same across all jobs.

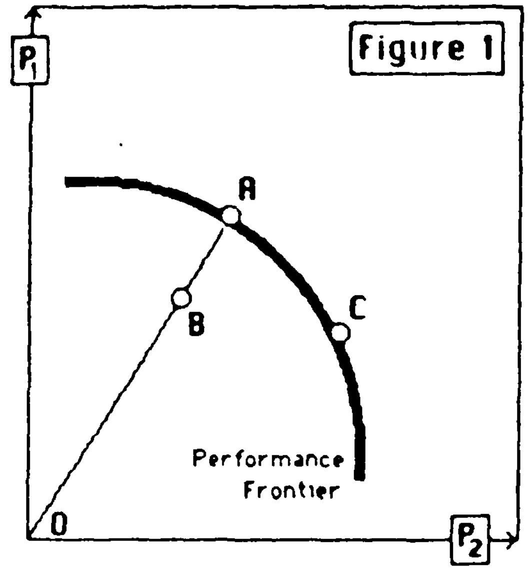


Figure 1
P1
A
B
C
Performance
Frontier
0
P2

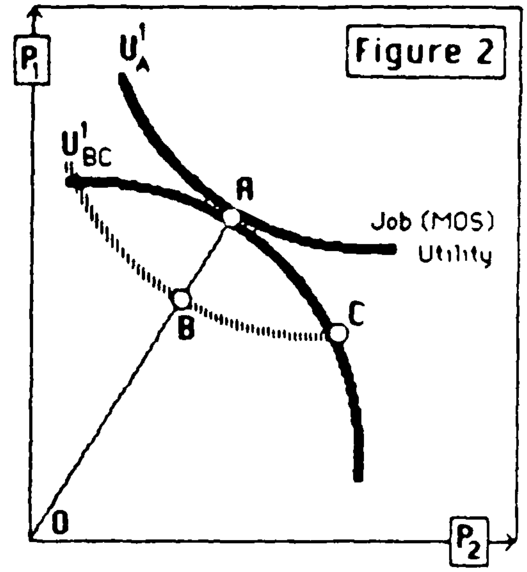
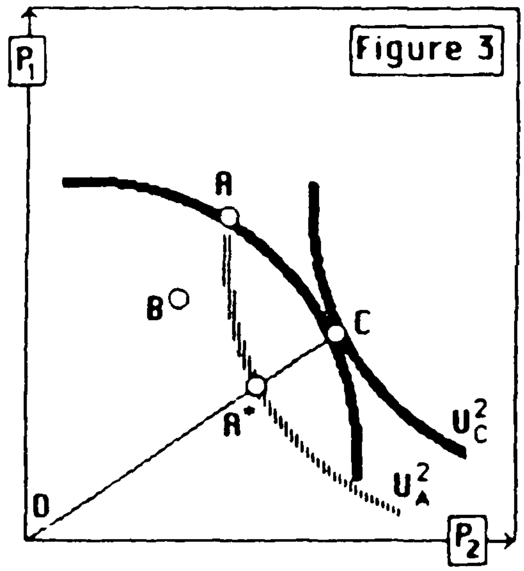


Figure 2
P1
U1A
U1BC
A
Job (MOS)
Utility
B
C
0
P2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A
B
C
A*
U2C
U2A
0
P2

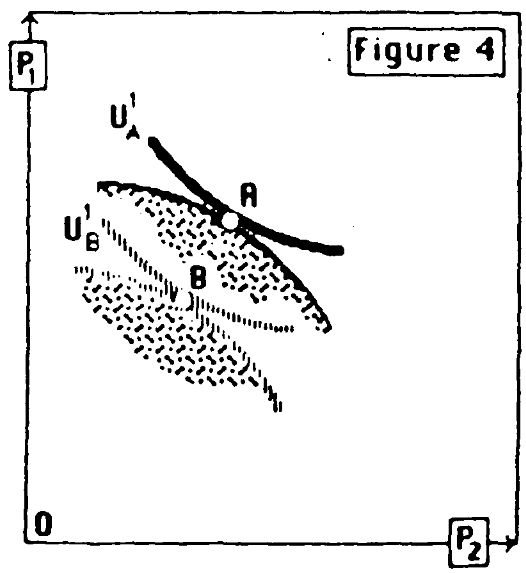
Figure 4
P1
U1A
A
U1B
B
0
P2

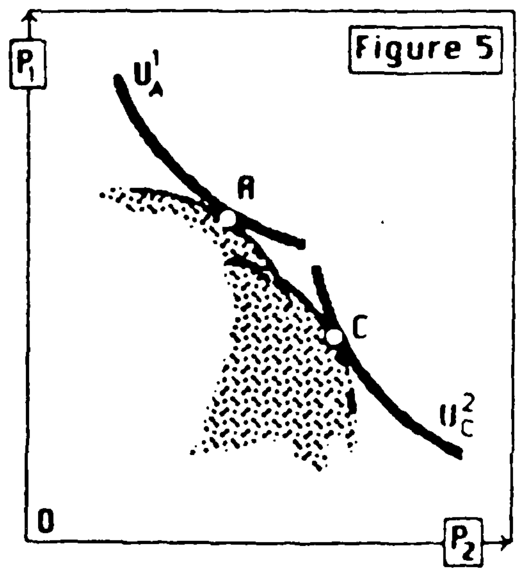
Figure 5
P1
U1A
A
C
U2C
0
P2

## Value of Performance

So far, we have been concerned only with the "quantity" of performance. The frontier shown in Figure 1 represents a range of combinations of the two performance attributes that are equivalent in the sense that the amount of one attribute can be increased only at the expense of a reduction in the amount of the other. Figures 2-3 introduce the notion that all of these combinations are not equally valuable or useful.

Figure 2 adds two utility functions to the performance data in figure 1. The curve $U_1$ is an "iso-utility" surface -- that is, a trade-off surface between the value to the Army of the soldier performance attributes in a particular job (say, job 1). Every combination represented by the curve is of equal utility, and the further away $U_1$ is from the origin, the higher the utility. Soldier A is located on utility surface $U_{1,A}$, whereas B and C are on $U_{1,BC}$ -- the value of Soldier A's performance on job 1 is higher than that of Soldier C. Although C is considered a frontier soldier, C's performance is valued less than A's (in fact, no more than B's) if C is assigned to job 1.

By contrast, when the utility function for job 2 is introduced in Figure 3, Soldier C's performance is valued most, followed by A and B. Since no other soldier can have a higher value of performance on job 2 than $U_C$, Soldier C forms the reference point for maximum performance on that job. For example, Soldier A, though superior to any other soldier on job 1, has a performance value inferior to C if assigned to job 2. Point $A^*$, at the intersection of the line segment OC and the utility curve $U_A$, locates a hypothetical soldier with the same performance attribute mix as soldier C, but with the job performance value of Soldier A. The ratio of $OA^*$ to OC may be used to construct an index of job value performance for A (say, 0.75).

The distinction between the level of performance and the value of performance made in Figures 2 and 3 is important. Figure 3 shows how a potentially superior soldier C, when mis-assigned to job 1, will have the job performance value of an inferior soldier, B. Similarly, the superior performance value of Soldier A in job 1 declines considerably when A is

assigned to job 2 in Figure 3. In fact, a properly assigned non-frontier (inferior) soldier may produce a higher value of performance than a poorly assigned frontier (superior) soldier.

Recruitment of high quality personnel and their subsequent training must therefore be followed by proper job assignment to fully realize the potential of recruits and to assure the highest job performance for the armed forces. In fact, poor job assignments may completely undo the benefits to be derived from improvement in the quality of recruits. In years when good job opportunities in the economy lower the intake of high quality recruits, improved job assignments may improve performance and be more cost-effective than "expensive" inducements offered to recruits.

## EMPIRICAL ANALYSIS

The empirical analysis in this paper focuses on an illustrative development of a multi-dimensional measure of soldier performance and on tests to determine whether this measure of performance is (a) positively related to the traditional measures of recruit quality; and (b) how this relationship varies across jobs.

In addition, we shall address the following two general issues:

1. <u>Are there systematic differences in the average level of soldier performance across jobs</u>? This question will be explored by constructing a single performance index for all jobs (an "Army-Wide" performance index), and comparing the distribution of this measure within each of four MOS. Figure 4 provides a graphic illustration of the pattern we seek to elucidate in this part of the analysis. Performance frontiers for two different jobs ($Q_1$ and $Q_2$) are shown, along with the groups of soldiers associated with each frontier. Both the level and the value of performance in job 1 is clearly inferior to that in job 2. The purpose of this analysis is descriptive -- that is, to see whether discernable differences across MOS exist. Possible causes for such differences include the following:

(a) Variations in the value of "output" from different jobs combined with constraints on the supply of high performers result in the assignment of the best performers to the most "valuable" jobs.

(b) High performers are in a better "bargaining position" in the assignment process. In this case, the inter-job variations in performance level will reflect the attractiveness of the job to recruits rather than its value to the Army.

(c) Variations in the Army-wide measure across jobs simply reflect the degree to which the components of that measure contribute to job-specific performance in different jobs. If this is the case, then the jobs with high levels of performance in the Army-wide model are simply those in which the attributes of performance that are common to all jobs are relatively more important than are job-specific attributes.

The data available for the current analysis is insufficient to unequivocally distinguish among these potential causes, but, by identifying the patterns of variation that do exist, we hope to suggest some causal hypotheses that can be tested in further research.

2. <u>How does the job-specific performance of soldiers vary with the mix of performance attributes?</u> We will examine cross-job differences in both average levels and the degree of variation in performance. The performance measure used in this analysis is MOS-specific. That is, the soldiers in each job are measured relative to the performance frontier for that job, and the dimensions of the performance space are defined by MOS-specific, as opposed to Army-wide components. To the extent that the performance attributes included in our analysis adequately span the performance space in the jobs analyzed, the patterns of performance identified in this analysis should reflect the variations across jobs in the <u>mix</u> of attributes required.

Figure 5 illustrates such a pattern. It shows two groups of soldiers, A and C, assigned to two jobs with performance frontiers $Q_1$ and $Q_2$. Groups A and C have distinctly different strengths: group A is superior to group C in job knowledge ($P_1$) but inferior in adaptabilty ($P_2$). The variance in performance level in group C is larger than that of group A.

## Data

Data were obtained from a sample of 677 soldiers in four Military Occupation Specialties (MOS) from the Combined Criterion Field Test variables developed by the Army Research Institute (Eaton, et.al.,1984). The four Military Occupation Specialties (MOS) consist of both combat and support personnel: armor crewmen (19E), infantrymen (11B), medical specialists (91A) and wheel vehicle mechanics (63B). Each MOS comprises approximately 25% of the total observations.

The principal types of measures used to capture the attributes of performance include the following:

- Job Knowledge Tests include items identfied as "common tasks" as well as items identified as "unique" tasks. The average score (percent correct) on common tasks is used in the Army-wide model, and the comparable score on unique tasks is used in the MOS-specific model.
- Hands-on Tests also include both common and unique tasks. The "percent go" on each subset is used in the Army-wide and MOS-specific analyses respectively.
- School Knowledge Tests are written multiple choice tests that reflect the degree to which the soldier has successfully absorbed the information imparted during MOS-specific training. Scores (number correct) on these tests are used in the MOS-specific models.
- Supervisor Performance Ratings include ratings (on a scale of 1 to 7) of common and job-specific tasks, overall effectiveness and leadership potential.

## Methodology

The data envelopment analysis (DEA) method was used to construct a "best practice frontier" of soldier performance as described in Figure 1. (The surface constructed is called a "best practice frontier" because the frontier is defined by the best practice (in our case, the most proficient soldiers) actually observed, rather than in terms of some theoretically attainable maximum.) DEA identifies the frontier soldiers and forms a piece-wise linear convex envelopment of the remaining soldiers in the performance space. The

position of each soldier relative to the frontier of best performance is measured along a ray passing through the observation and the origin. Using the procedure described in the discussion of Figure 1, the method computes an index of relative performance for each soldier in the data set. DEA is based on ideas introduced by Farrell (1954). The methodology was developed by Charnes, Cooper and Rhodes (1978), and is applied via an algorithm designed by Schinnar (1980).

The most common applications of DEA have been to the estimation of production functions and the measurement of productivity in the public sector (add a couple of citations). One of the particular strengths of the DEA approach for these purposes is the fact that the results it produces are unaffected by the units in which the data are measured. This feature is particularly important when, as is often the case in the public sector, the quantities being analyzed cannot be easily transformed into a single unit of measurment such as dollars.

The use of DEA as a means of constructing indices has been less common, but a number of such applications are described in the literature (see, e.g., Schinnar, et. al., 1986; Desai, et. al., 1986). The use of the technique within the current context can be illustrated for the two-dimensional case with reference to Figure 1. Each observation is located in the space defined by the dimensions P1 and P2, and a convex hull enclosing the set of all soldiers is constructed. The portion of the convex hull defined by those observations that are the "farthest" from the origin is the "best practice frontier". This will be a linear approximation to the curve AC depicted in Figure 1. The value of the index for each observation is then calculated as the length of a ray from the origin to the observation divided by the length of a ray passing through the observation and terminating at its intersection with the frontier. For soldier B in Figure 1, this will be the ratio OB/OA.

In the second phase of our analysis, we explore the distribution of soldier performance within the performance space defined by the DEA. This is done by using the performance index as a dependent variable in a multiple regression model. Our primary interest in this analysis is in examining the relationship between the recruit quality indicators -- AFQT score and

educational attainment -- and the performance index. Also among the explanatory variables used in the regressions are ratios of the dimensions used to construct the index. The coefficients on these ratios provide indications of the effect of the mix of performance attributes on performance in different jobs. An illustration of this is provided in Figure 6. Soldiers with high ratios of P1 to P2 tend to lie farther from the frontier than those where the reverse is true, indicating that, in this job, performance among soldiers with relatively high levels of "adaptability" tends to vary less than it does if the reverse is true. A regression of JK/AD on the performance index in this case would produce a negative coefficient on the ratio.

## EMPIRICAL RESULTS

### Performance Indices

Table 1 describes the specific variables used as performance attributes in the construction of the Army-Wide performance index. Table 2 provides similar information for the MOS-specific analysis.The correlations among the dimensions are given in Tables A1 - A5 of the Appendix.

## TABLE 1
## Army-wide Performance Model

| Variable Name | Description |
|---|---|
| 1. AWB | Supervisor performance rating: Army-wide Behaviorally Anchored Scale (BARS): Mean Rating. Soldiers are rated on a scale of 1-7 by their supervisors on general skills, including effort, integrity, leadership, following regulations, military appearance, etc. |
| 2. NCO | Supervisor Performance Rating of NCO potential. |
| 3. JKCOMM | Job Knowledge Test: Average % Correct for all Common Tasks. |
| 4. HOCOMM | Hands-On Performance Measure: Average % Go for Common Tasks. |
| 5. EFFECT | Supervisor Performance Rating of Overall Effectiveness |

## TABLE 2
## MOS-Specific Model

| Variable Code | Description |
|---|---|
| 1. PERF | Superivisor Performance Rating: Overall Effectiveness Rating. Soldiers are given an overall rating by their supervisors on their performance of major areas of their jobs. For instance, armor crewmen are rated on maintainence of tanks, engaging targets with tank guns, driving and recovering tanks, etc. |
| 2. SK | School Knowledge Written Test: Number correct |
| 3. MOB | Supervisor Performance Rating: MOS BARS Mean Rating. Soldiers are rated by their supervisors on MOS-specific skills. |
| 4. HOUNQ | Hands-On Performance Measure: Average % Go for Unique (MOS-specific) Tasks. |
| 5. JKUNQ | Job Knowledge Test: Average % for all Unique Tasks. Average percent correct on tests of specific items of information required to perform selected MOS-specific tasks. |

Summary statistics for the performance indices produced by the Army-wide and MOS-specific models are provided in Tables 3a and 3b. Table 3a shows means and standard deviations of the Army-wide index across all observations as as well as the differences in performance on this index across jobs. Table 3b provides similar statistics for each MOS-specific performance index.

TABLE 3a
Summary Statistics
Army-Wide Performance Index by MOS

| | N | MEAN | STD DEV | MIN | MAX |
|---|---|---|---|---|---|
| ARMY-WIDE | 467 | .834 | .096 | .499 | 1.00 |
| MOS 11B | 134 | .825 | .100 | .567 | 1.00 |
| MOS 19E | 93 | .790 | .102 | .499 | 1.00 |
| MOS 63B | 112 | .827 | .082 | .583 | 1.00 |
| MOS 91A | 128 | .880 | .080 | .603 | 1.00 |

TABLE 3b
Summary Statistics
MOS-Specific Performance Index

| | N | MEAN | STD DEV | MIN | MAX |
|---|---|---|---|---|---|
| MOS 11B | 138 | .846 | .107 | .529 | 1.00 |
| MOS 19E | 96 | .892 | .076 | .678 | 1.00 |
| MOS 63B | 137 | .892 | .072 | .733 | 1.00 |
| MOS 91A | 142 | .897 | .063 | .734 | 1.00 |

Figure 7 shows the frequency distribution of the performance scores for the Army-wide index. The distributions of the MOS-specific performance indices follow a similar pattern.

## Regression Analysis

The logarithms of the performance indices were regressed on a host of independent variables, including the logarithm of AFQT squared, paygrade, civilian education, race, prior service, and a set of ratios among the components of the performance index. (A second set of regressions that included a selected set of temprement scales were also run to explore the effect of these variables on the estamated coefficients. Inclusion of these

variables substantially improved the goodness of fit of the model, approximately doubling the $R^2$ statistics, but had no appreciable effect on the coefficients. The results of these regressions are reported in Tables A6-A10 of the Appendix.)

The general form specified for the regression models was:

$$\ln p = \alpha_0 + \alpha_1[.5(\ln q)^2] + \sum_{i=2}^{k} \alpha_i x_i \qquad (7)$$

where p is the performance index, q is AFQT percentile score, and $\{\alpha_i\}$ are the estimated coefficients associated with the independent variables $\{x_i\}$. This specification is similar to functional forms frequently estimated in economic studies. With $x_i$ expressed in logarithmic form it becomes a quadratic function in the logarithm of the variables, resembling the VES (variable elasticity of substitution) and the Translog functions (see Christiansen, Jorgenson, and Lau, 1973). In (7) we omit quadratic terms other than AFQT because they give rise to severe collinearity problems in the estimation of parameters.

The results of the regression models, are provided in Table 4. The first column of coefficients are for the model using the Army-wide performance index as the dependent variable. The remaining columns present results for each of the four MOS-specific models.

The implications of the coefficients for the Army-wide model, which explains approximately 20% of the variance in the Army-wide performance index include the following:

- The effect of AFQT on performance is positive and significant. This result will be discussed further in the following section.
- The negative and significant coefficients on the dichotomous variables for MOS indicate that the mean level of performance in the reference group, MOS 91A, is higher than that of any of the other three MOS.
- Soldiers in paygrades 1-3 tend to have lower performance indices than do E-4 soldiers. This finding may reflect either the positive effect experience or the fact that high-performing soldiers tend to be promoted rapidly (see Nord and Daula, 1986).

TABLE 4
REGRESSION RESULTS

| VARIABLE | DESCRIPTION | ARMY-WIDE | MOS 11B | MOS 19E | MOS 63B | MOS91A |
|---|---|---|---|---|---|---|
| INTERCEPT | | -.2128**<br>(.0431) | -.5537**<br>(.1211) | -.5570**<br>(.1403) | -.2282**<br>(.0838) | -.3237**<br>(.0997) |
| LAFQTSQ | $.5\ln(AFQT)_2$ | .0100**<br>(.0040) | .0204**<br>(.0084) | .0131*<br>(.0072) | .0130**<br>(.0052) | .0199**<br>(.0059) |
| E1 | 1 if in grade E1, 0 otherwise | -.0446<br>(.0287) | .0920<br>(.0639) | | -.0942**<br>(.0288) | -.0166<br>(.0340) |
| E2 | 1 if in grade E2, 0 otherwise | -.0512**<br>(.0232) | -.1296**<br>(.0620) | -.0830*<br>(.0430) | -.0813**<br>(.0223) | .0277<br>(.0539) |
| E3 | 1 if in grade E3, 0 otherwise | -.0521**<br>(.0129) | -.0461*<br>(.0261) | -.0161<br>(.0275) | -.0257<br>(.0179) | -.0167<br>(.0153) |
| COLLEGE | 1 if more than 12 yrs education, 0 otherwise | -.1415**<br>(.0586) | | -.0546<br>(.0916) | | -.0151<br>(.0510) |
| HSDG | 1 if HS diploma and no college, 0 otherwise | -.0006<br>(.0182) | -.0288<br>(.0406) | -.0369<br>(.0406) | .0201<br>(.0214) | .0004<br>(.0205) |
| HISPANIC | 1 if Hispanic, 0 otherwise | .0196<br>(.0372) | | | | |
| WHITE | 1 if White, 0 otherwise | .0219<br>(.0143) | .0340<br>(.0270) | .0143<br>(.0282) | .0301<br>(.0190) | .0062<br>(.0159) |
| OTHER | 1 if not white, hispanic or black, 0 otherwise | .0508*<br>(.0287) | | | | |
| MALE | 1 if male, 0 if female | .0146<br>(.0205) | | | | -.0044<br>(.0159) |
| JKCOMM / AWB | Ratio: Job Knowledge to Army Wide BARS | .0000<br>(.0015) | | | | |
| JKCOMM / HOCOMM | Ratio: Job Knowledge to Hands-on % GO | .0002<br>(.0012) | -.0464<br>(.0342) | .1457*<br>(.0781) | -.0449<br>(.0659) | -.0899<br>(.0562) |
| SK / MOB | Ratio: School Knowledge to MOS BARS | | .0031<br>(.0025) | .0018<br>(.0019) | .0014<br>(.0010) | .0001<br>(.0023) |
| PERF / MOB | Ratio: Sup. Rating of Overall Performance to MOS BARS | | .2539**<br>(.0907) | .1700<br>(.1410) | .0109<br>(.0552) | .1323**<br>(.0673) |
| PRIORSVC | 1 if soldier has prior service, 0 otherwise | -.0157<br>(.0283) | .0092<br>(.0645) | -.0046<br>(.0497) | .0736**<br>(.0352) | -.0330<br>(.0329) |
| MOS11B | 1 if infantryman, 0 otherwise | -.0653**<br>(.0183) | | | | |
| MOS19E | 1 if tank crewman, 0 otherwise | -.1235**<br>(.0294) | | | | |
| MOS63C | 1 if wheel vehicle mechanic, 0 otherwise | -.0875**<br>(.0183) | | | | |
| R-SQUARED (UNADJUSTED) | | .1919 | .3342 | .3864 | .3369 | .2037 |
| DEGREES OF FREEDOM | | 336 | 95 | 39 | 75 | 92 |

* = significant at the 10% level
** = significant at the 5% level
Standard errors in parentheses.

- The effect of some college education on the Army-wide performance negative and significant. This result at first seems surprising. However, the results of previous research on the relationship between education and various unidimensional measures of job performance have been mixed. Horne (1986), for instance, found no significant relationship between possession of a high school diploma and Skill Qualification Test (SQT) scores in any of the twelve MOS he examined. One possible reason for this may be the "screening" effect of the enlistment and training process among soldiers with low education. In effect, the non-high school soldiers whose performance we measure are the "cream" of the non-high school population, while the soldiers with more education are more typical of the general population.

The MOS-specific models explain a larger share of the variance in their respective performance indices: 33% for infantrymen, 39% for armor crewmen, 34% for mechanics and 20% for medics. The implications of the coefficients include:

- The effect of mental aptitude as measured by AFQT score is positive and significant in all four MOS.

- The effect of civilian education is not statistically significant in any MOS.

- There appears to be no systematic relationship between race and our measure of job performance. This result differs from the findings in many previous analyses, especially those that use SQT scores as performance measures (see, eg. Horne, 1986). This difference suggests that the multi-dimensional index employed here may indeed capture components of soldier performance that are not included in the more common uni-dimensional measures.

- In those cases where the coefficients are statistically significant, low paygrade is negatively related to performance, this effect is insignificant at all levels for MOS 91A.

- The pattern of significant coefficients on the "attribute ratio" variables across jobs is interesting. Significant coefficients on these variables imply that the attributes composing the performance index contribute differentially to the overall value of the index. Thus, the positive and significant effect of PERF/MOB among armor crewmen and medical specialists suggest that, in these jobs soldiers with high overall effectiveness ratings and low MOS BARS tend to receive higher overall performance scores than do soldiers for whom the reverse is true. Among mechanics there are no discernable assymetries in the contributions of the attributes, while armor crewmen with high ratios of job knowledge to hands-on performance tend to do well.

## AFQT and Soldier Performance

Table 5 provides summary statistics on the distribution of AFQT scores across jobs in our sample. Across all jobs, AFQT ranges from 12 to 99, with a sample mean of 48.6 and a standard deviation of 21.5. Scores are the highest among medical specialists, with a mean of 59.4, followed by 50.5 among armor crewmen, 43.9 among mechanics, and 41.2 for infantrymen. In spite of this considerable variation in means, the standard deviation remains remarkably stable at about 20.

TABLE 5

AFQT Summary Statistics by MOS*

| | N | MEAN | STD DEV | MIN | MAX |
|---|---|---|---|---|---|
| TOTAL | 533 | 48.597 | 21.462 | 12 | 99 |
| MOS 11B | 149 | 41.201 | 20.897 | 12 | 99 |
| MOS 19E | 124 | 50.468 | 21.009 | 15 | 99 |
| MOS 63B | 125 | 43.904 | 19.528 | 15 | 95 |
| MOS 91A | 135 | 59.385 | 19.659 | 21 | 98 |

*AFQT scores based on 1980 norms.

Denoting AFQT score by q, note that the AFQT variable in the regressions is in the form

$$LAFQTSQ=.5(\ln q)^2. \qquad (8)$$

Recall from equation (7) that the dependent variable in the regressions is the natural log of performance (lnp). Thus, to compute the "performance elasticity" of AFQT, or the proportional increase in performance due to a proportional increase in AFQT, we differentiate equation (7)

$$\frac{\partial \ln p}{\partial \ln q} = \alpha_1 \ln q \qquad (9)$$

where $\alpha$ is the estimated parameter of LAFQTSQ in Table 4 (and the subscript on $\alpha$ has been dropped for notational convenience). Since

$$\frac{\partial \ln p}{\partial \ln q} = \frac{\partial p}{\partial q}\,\frac{p}{q} \qquad (10)$$

it follows that the marginal gain in performance to to a marginal increase in AFQT is expressible via

$$\frac{\partial p}{\partial q} = \alpha_1 (p/q) \ln q \qquad (11)$$

Observe that (11) forms the numerator of the left-hand side of equation (6),. and that the elasticity of p with respect to q, or the proportional increase in performance resulting from a small increase in AFQT, increases logarithmically as AFQT rises. Since (9) is monotonically increasing with q, the effect of an increase in AFQT on performance is largest in the upper ranges of AFQT.

We can estimate performance elasticities for changes in AFQT around the mean for each job by inserting the the mean AFQT scores from Table 5 and the mean performance ratings from Table 3b into (11). These results, reported in Table 6, show that the most rapid gains in MOS-specific performance can be acheived by increasing the mean AFQT score of medical specialists, followed by infantrymen, armor crewmen and mechanics.

TABLE 6
Performance Elasticities with Respect to AFQT by MOS

| | Medical Specialists | Infantrymen | Armor Crewmen | Wheel Vehicle Mechanics |
|---|---|---|---|---|
| Parameter ($\alpha_1$) | .020 | .020 | .013 | .013 |
| Elasticity ($\alpha_1 \ln q$) | .081 | .076 | .051 | .049 |

To illustrate these effects, consider an increase of one standard deviation in the mean AFQT of armor crewmen. This would be a 40% increase in the average AFQT score in MOS 19E (see Table 5). Multiplying this by the elasticity of .051 yields a predicted 2.0% gain in average performance. Taking 2% of .892 (the mean performance in 19E from Table 3b) yields .018, which is is approximately one fourth of the standard deviation of performance (.076) in this MOS (see Table 3b). In comparison, a standard deviation increase in the mean AFQT of medical specialists, about 33%, would yield an expected gain in the average performance level of about 2.7% -- an increase of nearly 40% of the standard deviation of performance.

How do our estimates of performance elasticities compare with the literature? The only estimates available are those reported by Scribner, Smith, Baldwin and Phillips (1986) for armor crew performance in simulated conditions on a standardized tank course. Their estimates are:

| | Gunner | Tank Commander |
|---|---|---|
| M-60 Tank | .20 | .15 |
| M-1 Tank | .10 | .01 |

The average of these elasticities is about .115. When the substantial differences in the measures of performance used in the two studies are considered, the estimated elasticities are more similar than we would have expected. In the study by Scribner, et. al., the performance measure used was the score acheived by the armor in 13 simulated engagements, each consisting of a different combination of main gun and machine gun targets. The performance measure on which our elasticities are based is different not only in its reliance on a broader set of indicators, but also in its coverage of all armor crewmen, including drivers and loaders.

## Recruitment Cost and Soldier Performance

To obtain an expression for the relationship between soldier performance, recruit quality and recruitment costs, we note that the denominator of equation (6), $\partial c/\partial q$, reflects the marginal cost of increasing the quality of the recruit pool. To obtain a precise estimate of this quantity would require the estimation of a recruit cost function. In the absence of such an estimate, however, we can invoke an equality between marginal and average cost in order to establish benchmark estimates for the left-hand side of (6). This implies that we assume

$$\frac{\partial c}{\partial q} = \frac{c}{q} . \qquad (12)$$

From (2) and (3) we have

$$\frac{dp}{dc} = \frac{\partial p/\partial q}{\partial c/\partial q} . \qquad (13)$$

Hence, by inserting (11) and (12) into (13) we obtain

$$\frac{dp}{dc} = \alpha_1 (p/c) \ln q \qquad (14)$$

an explicit expression for computing the incremental gains in productivity resulting from a small increase in recruitment expenditure. These are computed for each MOS as follows:

| Medical Specialists | Infantrymen | Armor Crewmen | Mechanics |
|---|---|---|---|
| .073/c | .064/c | .045/c | .044/c |

These figures suggest that, as might be expected, recruitment expenditures provide diminishing marginal returns in terms of expected job performance. They also provide useful indicators of the impact of changes in recruitment expenditures on the margin. They suggest, for instance that, if the Army were able to allocate recruiting resources by MOS, it would receive a return (in terms of job performance) on additional dollars invested in recruiting medical specialists almost twice as large as that for additional expenditures on recruitment of mechanics. Alternatively, given the fact that recruiting is not MOS-specific, this result implies the performance return on recruiting resources expended under the current system would be maximized by assigning a higher proportion of "expensive" (i.e., high quality) recruits to MOS 91A than is currently the case. It is important to note, however, that this implication is true only if the marginal value of performance is the same for all MOS. Since we do not have information on the value or utility of an incremental increase in the performance of medical specialists relative to mechanics, it is not possible to ascertain whether changes in current assignment policies would be cost effective.

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APPENDIX A

CORRELATIONS AMONG VARIABLES USED
TO CONSTRUCT PERFORMANCE INDICES

## TABLE A-1
## CORRELATIONS AMONG VARIABLES USED TO CONSTRUCT THE ARMY-WIDE PERFORMANCE INDEX

| | AWB | NCO | JKCOMM | HOCOMM | EFFECT |
|---|---|---|---|---|---|
| AWB (Army-wide BARS, Supv) | 1.00 | .792 (.0001) | .157 (.0006) | .075 (.1066) | .844 (.0001) |
| NCO (Supv Rating of NCO Potential) | | 1.00 | .162 (.0004) | .019 (.6796) | .746 (.0001) |
| JKCOMM (Job Knowledge, Avg % Corr, Common Tasks) | | | 1.00 | .095 (.0398) | .184 (.0001) |
| HOCOMM (Hands-on tests, Avg. % GO, common tasks) | | | | 1.00 | .055 (.2345) |
| EFFECT (Supv rating of Overall Effectiveness) | | | | | 1.00 |

Pearson Correlation Coefficents
Probability > IRI under H0: RHO=0 in parentheses
Number of observations = 467

Note: Low correlations between many of the variables in both Army-wide and MOS-specific models suggests that the measures are providing independent information -- i.e., that the performance indices are capturing more than one performance dimension.

## TABLE A-2
## CORRELATIONS AMONG VARIABLES USED TO CONSTRUCT THE PERFORMANCE INDEX FOR MOS 11B (Infantrymen)

| | PERFORM | SK | MOB | HOUNIQ | JKUNIQ |
|---|---|---|---|---|---|
| PERFORM (Supv Rating of overall perf, MOS tasks) | 1.00 | .167 (.0501) | .800 (.0001) | .289 (.0006) | .323 (.0001) |
| SK (School Knowledge Test, # Correct) | | 1.00 | .225 (.0080) | .384 (.0001) | .736 (.0001) |
| MOB (MOS BARS, Supv Rtng) | | | 1.00 | .358 (.0001) | .285 (.0007) |
| HOUNIQ (Hands-on tests, Avg. % GO, unique tasks) | | | | 1.00 | .526 (.0001) |
| JKUNIQ (Job knowledge, Avg % Corr., Unique Tasks) | | | | | 1.00 |

Pearson Correlation Coefficents
Probability > IRI under H0: RHO=0 in parentheses
Number of observations = 138

TABLE A-3
CORRELATIONS AMONG VARIABLES USED TO CONSTRUCT THE PERFORMANCE INDEX FOR MOS 19E (Armor Crewmen)

| | PERFORM | SK | MOB | HOUNIQ | JKUNIQ |
|---|---|---|---|---|---|
| PERFORM (Supv Rating of overall perf, MOS tasks) | 1.00 | .246<br>(.0158) | .817<br>(.0001) | .025<br>(.8089) | .353<br>(.0004) |
| SK (School Knowledge Test, # Correct) | | 1.00 | .337<br>(.0008) | .270<br>(.0078) | .623<br>(.0001) |
| MOB (MOS BARS, Supv Rtng) | | | 1.00 | .117<br>(.2549) | .311<br>(.0021) |
| HOUNQ (Hands-on tests, Avg. % GO, unique tasks) | | | | 1.00 | .423<br>(.0001) |
| JKUNIQ (Job knowledge, Avg % Corr., Unique Tasks) | | | | | 1.00 |

Pearson Correlation Coefficents
Probability > |R| under H0: RHO=0 in parentheses
Number of observations = 96

TABLE A-4
CORRELATIONS AMONG VARIABLES USED TO CONSTRUCT THE PERFORMANCE INDEX FOR MOS 63B (Wheel Vehicle Mechanics)

| | PERFORM | SK | MOB | HOUNIQ | JKUNIQ |
|---|---|---|---|---|---|
| PERFORM (Supv Rating of overall perf, MOS tasks) | 1.00 | .265<br>(.0018) | .817<br>(.0001) | .261<br>(.0020) | .165<br>(.0541) |
| SK (School Knowledge Test, # Correct) | | 1.00 | .231<br>(.0067) | .366<br>(.0001) | .639<br>(.0001) |
| MOB (MOS BARS, Supv Rtng) | | | 1.00 | .226<br>(.0078) | .120<br>(.1638) |
| HOUNIQ (Hands-on tests, Avg. % GO, unique tasks) | | | | 1.00 | .217<br>(.0110) |
| JKUNIQ (Job knowledge, Avg % Corr., Unique Tasks) | | | | | 1.00 |

Pearson Correlation Coefficents
Probability > |R| under H0: RHO=0 in parentheses
Number of observations = 137

TABLE A-5
CORRELATIONS AMONG VARIABLES USED TO CONSTRUCT THE PERFORMANCE INDEX FOR MOS 91A (Medical Specialists)

| | PERFORM | SK | MOB | HOUNIQ | JKUNIQ |
|---|---|---|---|---|---|
| PERFORM (Supv Rating of overall perf, MOS tasks) | 1.00 | .127<br>(.1313) | .875<br>(.0001) | .148<br>(.0792) | .092<br>(.2763) |
| SK (School Knowledge Test, # Correct) | | 1.00 | .136<br>(.0008) | .209<br>(.0078) | .412<br>(.0001) |
| MOB (MOS BARS, Supv Rtng) | | | 1.00 | .152<br>(.0715) | .118<br>(.1632) |
| HOUNIQ (Hands-on tests, Avg. % GO, unique tasks) | | | | 1.00 | .164<br>(.0508) |
| JKUNIQ (Job knowledge, Avg % Corr., Unique Tasks) | | | | | 1.00 |

Pearson Correlation Coefficents
Probability > IRI under H0: RHO=0 in parentheses
Number of observations = 142